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ABSTRACT

According to the Nation's Report Card released by Education Secretary Richard Riley, 51% of students from Georgia scored below basic science understanding level, and 95% of African American students performed below grade level in science understanding. Valdosta State University serves in the region to improve science teachers' skills. This region contains a high proportion of minorities and students from economically disadvantaged homes. This paper describes a project that aims to assist middle school and high school science teachers to: (1) become knowledgeable and effective using an inquiry-based teaching procedure (learning cycle) that is consistent with both state and national science education reform movements; and (2) obtain the necessary experience and skills using instructional technologies to incorporate them into the inquiry-based teaching procedure. Results suggest that teachers felt positive impact from using the learning cycle and incorporating technology on students and themselves, and indicated positive self-efficacy and increased interest in teaching. (YDS)

SITE-BASED PROFESSIONAL DEVELOPMENT: LEARNING CYCLE AND TECHNOLOGY INTEGRATION

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Project Goals and Objectives

Recent state and national reports verify the academic deficiencies of science students in this region of the country and call for changes in the way science is taught. The Nation's Report Card, released by Education Secretary Richard Riley, tested the science understanding of students in grades four, eight and twelve. Georgia students scored in the bottom 25% of students in the 40 states tested (Henry, 1997). In Georgia, 51% of the students scored at the "below basic" science understanding level. Moreover, 95% of African American students and approximately 95% of economically disadvantaged students (based on free or reduced lunches) performed below grade level in science understanding.

According to 1989-90 census data, African Americans comprise 30-50% of the population in 23 of the 50 Georgia counties surrounding Valdosta State University (VSU). In another nine of these counties, greater than 50% of the population is African American. Additionally, at least 30% of children (to age 18) live below the poverty level in 35 of these 50 south Georgia counties.

As a regional university of the University of Georgia System, VSU services the academic needs of the south Georgia region. This region contains a high proportion of minorities and students from economically disadvantaged homes. VSU must reach out to the science teachers of this area to improve their skills if their students are to become productive and contributing members of local communities.

According to the 1995-96 Georgia Public Education Report Card, the school district participating in this project contains a high percentage of African Americans (66%) and students qualifying for free/reduced lunches (78%). Two primary aspects of this project involved assisting middle school and high school science teachers of the district to 1) become knowledgeable and effective with an inquiry based teaching procedure (learning cycle) which is consistent with both state and national science education reform efforts (GIMS, 1996; NRC, 1996); and 2) obtain the necessary experience and skills with instructional technologies to incorporate them into the inquiry based teaching procedure.

Learning cycles consist of three phases: an exploration, a concept invention (also called term introduction) and an expansion. The exploration activities, usually laboratory experiments, provide students with the data needed to develop understandings of scientific concepts. The teacher-led concept invention phase follows the exploration. In this phase, students are guided in interpreting their data, thus inventing or constructing the science concept. As the students are developing understandings of the concept, the scientific terminology is provided. Following concept invention, the expansion phase provides for the application of the new concept; in other

words, students organize the concept in relation to what they already know. The expansion phase of the learning cycle may include but is not limited to additional laboratory investigations, textual readings and/or audio visual aids. The learning cycle is an instructional practice that is designed to allow for a variety of teaching methods (e.g., demonstrations, class discussions, student presentations, field trips) and state-of-the-art science equipment (e.g., computers, CD ROM, video technology).

The learning cycle is a laboratory-based teaching procedure derived from the intelligence model of Jean Piaget (Lawson, 1995; Renner & Marek, 1990). Intellectual development, according to Piaget (1964), takes place when students assimilate information from experiences (exploration), then accommodate the new information (concept invention). Previously held ideas or concepts must then be adjusted and organized with respect to the new information (expansion).

The results of past learning cycle institutes, sponsored by the National Science Foundation, have documented long term changes in the teacher participants (Marek, Haack, & McWhirter, 1994). The most significant finding from these studies is that 93% of the participating science teachers continue to use the learning cycle teaching procedure and/or curricula in their science programs nearly a decade after the institutes. Teachers stated that the learning cycle teaching procedure:

- extensively involved students in the learning process,
- produced deeper understandings and greater retention of concepts,

- developed students' thinking and communication skills,
- included teaching science process as well as content,
- was based upon learning theory and supported by empirical data, and
- made science relevant and meaningful to students.

We expected this project to have a similar impact on the teacher participants and students of these participants. In addition, this project was congruent with highly regarded science education reform documents. Described below are the major ideas of NSES and Project 2061 that were directly associated with this project.

National Science Education Standards (National Research Council, 1996).

> Teachers of science should plan an inquiry-based science program for their students, guide and facilitate learning, engage in ongoing assessment of their teaching and of student learning, and actively participate in the ongoing planning and development of the school science program. Professional development for teachers of science requires learning essential science content through the perspectives of inquiry; requires integrating and applying knowledge of science, learning, pedagogy and students; and must be coherent and integrated. As a result of activities in secondary science all students should: develop abilities necessary to do scientific inquiry and understandings about scientific inquiry, and develop understanding of science as a human endeavor and the nature of

science knowledge. The program of study for all students should be developmentally appropriate, interesting, and relevant to students' lives; emphasize student understanding through inquiry; and be connected with other school subjects.

Science for all Americans: Project 2061 (American Association for the Advancement of Science, 1990). Learning is not necessarily a natural outcome of teaching. Cognitive research strongly suggests that students know less than we think they do following instruction. The quality of student understanding should be emphasized rather than the quantity of information presented. Students must construct their own meaning regardless of how clearly teachers or books tell them things. The dependence of most people on concrete examples of new ideas persists throughout life. Students learn most readily about things that are directly accessible to their senses - tactile, kinesthetic, visual, and auditory. Teaching should be consistent with the nature of scientific inquiry. Science, mathematics and technology is defined as much by what is done and how it is done as it is by the achieved results. Students must have experience with the thoughts and actions prevalent in these fields. Teachers, therefore, should start with questions and phenomena that are interesting and familiar to students, engage students actively, concentrate on the collection and use of evidence, provide historical perspectives, insist on clear expression, use a team approach, not separate

knowing from finding out, and de-emphasize the memorization of technical vocabulary.

The key concepts described above from the NSES and Project 2061 formed the foundation of this project primarily through the use of the inquiry based, learning cycle teaching procedure. It places the students at the center of their learning experiences, encouraging them to engage in explorations, form new understandings and relate those understandings to other concepts. Additionally, several other important dimensions were incorporated into this project. These included the extensive use of technology in the learning cycle development sessions, the use of experienced inservice teachers to model inquiry based science lessons, establishment of an Advisory Panel, and extensive follow up and teacher support activities.

Proposed Activities

An Advisory Panel was responsible for the planning and implementation of the project. The Panel consisted of a science teacher, scientist, educational technologist, and two science education professors (one middle school and one secondary). The project included three phases. The first phase of the project, Exploration Phase, was designed to allow the teacher participants to explore the theoretical underpinnings of the learning cycle and experience the operation of a variety of instructional technology equipment available to them at their schools. The second phase, Application Phase, was designed to allow teachers to construct learning cycles and integrate technology into their curricula. The third phase of the project, Follow Up Phase, was one in which teachers applied the new found information and skills to their science curricula.

I. Exploration Phase

Twelve middle school and secondary school science teachers from the district participated. For a period of one week in the summer, these teachers met five days from 9am to 3pm at the district high school or middle school. During the first one and a half hours of each day, teachers met in seminar sessions. These seminars, led by science education professors, were devoted to examining a) the structure of science; b) the nature of human learning; and c) authentic assessment strategies for student evaluation in learning cycle curricula. The remainder of each day was spent in two laboratory sessions led by other members of the presentation team (teachers, scientist, education technologist). These sessions included technology laboratories, designed to familiarize teachers with the use of a variety of educational technologies available to them (e.g., computers, video technology) and how to incorporate these into their curricula; and science laboratories modeling the learning cycle teaching procedure led by inservice middle school and high school teachers experienced in the inquiry teaching procedure. The technology laboratories were led by the technology specialist or inservice teachers experienced at incorporating technology into the classroom. An important point to be made here is that each learning cycle investigated (an) important and easily recognizable scientific concept(s). That fact permitted the teachers in the workshop to review science content while they learned how to teach that content using learning cycles. A scientist was on staff to monitor the accuracy of the science content taught through the learning cycle demonstrations and acted as a science content reference

for the remainder of the staff and teacher participants. This phase of the project required teachers to meet with project staff at least 30 hours over the five-day period.

II. Application Phase

This phase began after the first two weeks of the start of school in August, 1998. Teacher participants met with the project staff every alternate Saturday for 8 weeks from 10am to 3pm (four total sessions over an eight-week period). These meetings took place in a science laboratory at the district high school or middle school.

During the Application Phase, teachers received a copy of the learning cycle science curricula of their choice - biology, chemistry, physics, general physical science, life science, earth science. In addition, all teachers brought their current science curricula so they could use the learning cycle curricula as a model to integrate with their science curricula. During each of these sessions, teachers in partnership with each other and the project staff, modified two weeks of their science curricula into inquiry based lessons. Successes/difficulties associated with implementing this inquiry-based curricula in their own science classrooms were discussed.

This phase of the project required teachers to meet with project staff at least 20 hours over the four meeting days. Communication with staff members, such as the scientist for questions pertaining to content, was encouraged through the use of electronic mail.

III. Follow Up Phase

The Follow Up Phase occurred through the remainder of the fall semester and throughout the spring semester. The Exploration and Application Phases of the project allowed teachers to

accommodate the inquiry based curricula and its theory base; but sound understanding comes with using the learning cycle in their science classrooms during the ensuing school year. Therefore, follow up meetings were a significant part of the project and occurred in many forms.

A member of the project staff observed each teacher in their classroom four times during the Follow Up Phase. These four observations occurred once during each of the months of November, February, March, and April. Following each observation was an individual meeting between the teacher and staff member to discuss the implementation of the inquiry teaching procedure, incorporation of technology, assessment, or other factors associated with the curricula.

In addition to these individual observations were two meetings with all teachers and project staff members to share successes/difficulties and to brainstorm solutions to problems any teacher may have encountered. These meetings took place after school from 3-5pm once in February and again in April.

The follow up part of this project resulted in at least 12 hours of contact time between each participant and the project staff. Total contact time with each teacher over the course of the project was estimated to be at least 60 hours. Teachers received six staff development units and a stipend of $100 for participation in this project.

Description of Participants

Teacher participants in the proposed project were middle school and high school science teachers from a rural school district located in south Georgia. All were currently certified to

teach science or were seeking certification to do so. Science department heads for the high school and middle school were a part of this group of teachers and participated in the project. One school district was chosen in order to provide participants with a strong collegial support network.

Evaluation Procedures

A thorough evaluation plan was implemented to assess program effectiveness with respect to teacher and student outcomes. The evaluation plan had substantial formative and summative aspects and placed particular emphasis on the domain of cognitive and affective development. Within these two domains, the evaluation instruments primarily measured: teacher attitudes and pedagogy; and student attitudes toward science and understanding of science concepts in general.

Results

Results of open-ended questionnaires administered to the teacher participants at the end of the school year indicated they felt the use of the learning cycle teaching procedure and integrating technology had important impacts on their students. Representative responses from the teachers included comments such as, "Students have begun to ask "why?" They have begun to look forward to class instead of dreading science/math activities." "My students have begun to think for themselves, and come up with their own explanations for various situations/events." When asked how the learning cycle approach has affected their interaction with students, the teachers responded that they enjoyed a more positive and productive student/teacher relationship since implementing the learning cycle in their classrooms. Typical comments included, "The learning cycle has helped foster a good working relationship in which we learn from each other. Creativity is at an all time high." "More movement and talking between us, but much more

interest and responsibility on their part." "The learning cycle has had a positive effect on my students. They enjoy the class more and look forward to activities in class."

When asked about their self-efficacy as a result of incorporating the learning cycle and technology in their classrooms, responses from the teachers indicated they felt they were doing a better job as a result of the project. Comments included, "More effective and with renewed interest. I'm out of a rut and thankfully so. The students enjoy the day to day change." "My students are retaining more information, which suggests to me that I am more effective in the classroom. My expectations have increased." "I feel more like the sign in my room which says that the teacher in this classroom is a highly trained professional with the necessary skills and motivation to manage an effective learning environment."

Discussion

This project involved middle school and high school science teachers in a 60-hour collaborative project that spanned an academic year. The primary emphasis of the project was the incorporation of the learning cycle teaching procedure and instructional technologies available to the science teachers in the participating district.

Results of the project indicated that teachers felt that using the learning cycle and incorporating technology where appropriate influenced current students, compared to those of past years, to exhibit greater interest in science, ask more questions of the teachers, cause less disruptive behaviors, and perform better on science examinations. The teachers themselves indicated a greater self-efficacy, and a renewed interest in teaching.

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